



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

MEMORANDUM

DATE: April 17, 2000

SUBJECT: **Chlorpyrifos-Methyl** - Revised HED Occupational and Residential Exposure Chapter for the HED Risk Assessment. Chemical Number 059102. DP Barcode D265058

TO: Mark Hartman, Chemical Review Manager
Reregistration Branch 2
Special review and Reregistration Division (7508C)

FROM: Gary Bangs, Industrial Hygienist
Reregistration Branch 3
Health Effects Division (7509C)

THRU: Steve Knizner, Branch Senior Scientist
Reregistration Branch 3
Health Effects Division (7509C)

A copy of the revised HED occupational and residential exposure chapter for the chlorpyrifos-methyl Registration Eligibility Decision (RED) is enclosed with this memo. The assessment was done in a "stream-lined" RED format.

Chlorpyrifos-methyl
Streamlined RED Format

Chemical Number: 059102

Products:

Dow Agrosiences Reldan F Technical Insecticide	Reg No 62719-42
Dow Agrosiences Reldan 4 E	Reg No 62719-42
Gustafson Reldan 4E Insecticide	Reg No 7501-41
Gustafson 3% Reldan Dust Insecticide	Reg No 7501-99
Gustafson 2% Reldan Dust Insecticide	Reg No 7501-98

Executive Summary - Occupational and Residential Exposure

There were no chemical-specific exposure data available for this chemical. Therefore, the risk assessment has been performed using surrogate data from the Pesticide Handler's Exposure Database (PHED, v. 1.1), where available. No data, surrogate or otherwise, were available for several pesticide handler scenarios.

Only short- and intermediate-term exposures are anticipated for handlers of this chemical. Absorbed daily doses (ADDs) were determined for dermal and inhalation exposure for these intervals. This product is typically applied by the farmer or an employee of the grain storage facility rather than a contracted professional applicator. Typical exposure for farmers is anticipated to be less than 7 days/year (short-term), but for grain storage facility workers, more than 7 but less than 180 days per year (intermediate-term).

Loader and applicator exposure were evaluated based on wearing long-sleeved shirt, long pants, chemical-resistant gloves, and shoes with socks; separate estimates were made with minimum label-required personal protective equipment and with maximum personal protective equipment. All of the Reldan labels require *only* gloves and eye protection.

The baseline, short-term, combined dermal and inhalation risk for two of the available application scenarios did not exceed HED's level of concern (the MOEs are over 100) for chlorpyrifos methyl (see Tables 2 and 3). Mixing/loading/applying with a high pressure wand had an MOE of 93 at baseline, and all scenarios for loading or application of dust had much lower MOEs. The baseline, intermediate-term, combined dermal and inhalation MOEs for all available exposure scenarios except mixing/loading liquids exceed the Agency's level of concern. The combined intermediate-term MOEs for chlorpyrifos methyl also exceed the Agency's level of concern, except for mixing and loading of liquid formulation (MOE 130). The combined dermal and inhalation risk estimates for all short-term exposure estimates using maximum PPE are below EPA's level of concern (MOEs are greater than 100). Several exposure scenarios (i.e., treating grain in truck or grain bin by hand or mechanical means with dust) have no exposure data available. An attempt was made to characterize dermal short-term exposure to dusts based on published exposure studies of the application of dust to gardens. The

MOEs calculated for the dust application scenario (dermal exposure only) were of concern, with a maximum short-term MOE of 21 with maximum PPE, even though it is anticipated that actual grain application exposures could be greater. Agricultural points-of-contact have stated hand application of dust is not widely practiced, but power-dusting is very common.

I. Exposure Characterization

Occupational workers are potentially exposed to chlorpyrifos methyl from the application of the following registered products:

- | | |
|--|-----------------|
| • Dow Agrosiences Reldan 4 E | Reg No 62719-42 |
| • Gustafson Reldan 4E Insecticide | Reg No 7501-41 |
| • Gustafson 2% Reldan Dust Insecticide | Reg No 7501-98 |
| • Gustafson 3% Reldan Dust Insecticide | Reg No 7501-99 |

Dow Agrosiences is also seeking reregistration of the following product for use in manufacturing only:

- | | |
|--|-----------------|
| c Dow Agrosiences Reldan F Technical Insecticide | Reg No 62719-42 |
|--|-----------------|

Chlorpyrifos methyl is an organophosphate insecticide used to protect stored grain, including wheat, barley, oats, rice, and sorghum. End-use product formulations consist of dusts containing 2% or 3% active ingredient (Reldan 2% and 3% Dust, respectively), and a liquid containing 43.2% active ingredient (Reldan 4E). Clean grain or grain bins may be treated with a residual amount of insecticide to protect against infestations. Chlorpyrifos methyl is the most commonly used post-binning insecticide and second most commonly used residual insecticide and insecticide treatment for empty bins in the U.S. Two-thirds of wheat storage bins are treated when empty, about one-half of storage sites use insecticide during binning, and one-third apply as top-dressing to wheat after binning.¹ About 80% of the total pounds of chlorpyrifos methyl ai is applied to wheat. The BEAD Quantitative Usage Analysis (Tim Kiely, 5/18/99) showed about 8 % of all stored wheat, 5% of sorghum and 5% of barley were treated with chlorpyrifos-methyl.

Currently there are no residential or non-occupational uses of chlorpyrifos methyl, and no residential exposures are anticipated based upon the grain treatment use.

II Incident Data

According to a review of the OPP Incident Data System and national and California state poisoning registries, “relatively few incidents of illness have been reported due to chlorpyrifos methyl.”⁵ Chlorpyrifos methyl was not in the top 200 chemicals reported to the National Pesticide Telephone Network in 1984-1991. Ten incidents of health effects which may have been associated with chlorpyrifos methyl were reported to the Poison Control Centers, four of which were seen by a health

care provider and one was hospitalized, but none with serious outcome. There was no California poisoning registry incidents recorded for chlorpyrifos methyl (1982-1995), and insufficient data on which to base recommendations.

III. Occupational Exposure Assessment

Based on the chlorpyrifos methyl pattern of use, several exposure scenarios are plausible as defined by the types of application equipment and procedures that might be employed by chlorpyrifos methyl handlers. The basic tenets in each scenario are put forth in Table 1: **Exposure Scenario Description for Uses of Chlorpyrifos methyl**. Table 1 summarizes the caveats and parameters specific to each exposure scenario. This table also includes a description of the sources for the exposure data as well as general information pertaining to the techniques used to calculate the corresponding exposure values. The quality of the data for each exposure scenario is also addressed. These assessments include the typical equipment used to treat grain.

The following assumptions and considerations were used for assessing occupational exposure to chlorpyrifos methyl:

Application Rates

The label rates for application to grain and empty storage bins were used to develop the application scenarios, as described in **Table 2: Assumptions Used in Estimating Worker Short and Intermediate-Term Exposure to Chlorpyrifos Methyl**.

Admixture: Pesticide is mixed with grain as it enters the storage container. The labels do not specify the type of equipment to use. For grain, Reldan 2% Dust is applied at a rate of 15 lbs of product (0.45 lbs ai) per 1000 bushels, and Reldan 3% Dust at 10 lbs product (0.3 lbs ai) per 1000 bushels. In contrast, the liquid Reldan 4E is diluted by mixing a label-specified quantity (depending on the type of grain) of pesticide with 5 gallons of water for each 1000 bushels of grain. Wheat is the largest treated commodity, so the rate at which Reldan 4E is applied to wheat (0.36 lb ai per 1000 bushels) is used for assessment purposes.

Top-Dress Treatment: Pesticide is applied to the top surface of stored grain to act as a barrier to infestation. [The grain may be fumigated with another product prior to the top-dressing.] The worker/applicator may climb into the storage container to add the dust. This can be physically stressful as the worker will typically sink in to knee depth or deeper. Sometimes dust is blown into the container from the opening. If the grain is in a truck or wagon, the dust formulation is applied and then “cut into the grain with a shovel,” prior to loading into the storage container. Due to the physical nature of this task, and based on consultation with agricultural authorities, HED estimated one applicator could treat a maximum of 3 large silos (2000 ft² each) or one farm truck per day. As a top-dressing, both the Reldan 2% and 3% dust are applied at 7 lb product per 1000 square feet. Reldan 4E liquid is not used for top-dressing, based on the label.

Empty Bin Treatment: Reldan 4E liquid is labeled for use as a bin treatment after removal of all grain and waste from the container. One pint of Reldan 4E is mixed with 3 gallons of water to provide an approximately 1% spray, which is then applied to walls and floors at one gallon per 650-1250 square feet. For assessment purposes, a one gallon/650 square feet rate (maximum label rate) was chosen. The application rate per day was based upon the HED policy for practical maximum daily spray volumes multiplied by square footage per gallon.

Dermal Absorption: According to the Hazard Identification Assessment Review Committee report of April 29, 1999, there are no dermal absorption studies available for chlorpyrifos methyl.⁶ Therefore, the committee extrapolated a dermal absorption factor from relevant data on the structurally related chemical, chlorpyrifos (ethyl). The estimated dermal absorption factor is 3% for chlorpyrifos methyl.

Personal Protective Equipment: The current label for Reldan® requires the following personal protective equipment for loaders: “Goggles or face shield and rubber gloves.”

Handler Exposure Estimates: For several scenarios, exposure data were very limited or unavailable. The most reliable exposure data are for mixing and loading liquid formula (i.e. for automated admixture systems) and for mixer/loader/applicators of the liquid form to empty grain storage bins. But only 5% of the annual usage of a.i. (based on Quantitative Usage Analysis dated 4/19/98 by BEAD) is for treatment of empty grain storage bins, and approximately 95% is for grain protection. Little exposure information is available for application of either the dust or liquid product to grain. Therefore, most of the exposure estimates were surrogate values derived from the Pesticide Handler Exposure Database (PHED) Version 1.1. Table 3: **Occupational Handler Short- and Intermediate-Term Exposure Estimate and Risk Assessment Summary for Chlorpyrifos Methyl** shows the calculations of worker exposure and MOEs for minimum protective clothing (long-sleeved shirt, long pants). Table 4 calculates the worker exposures and MOEs when wearing long-sleeved shirt, long pants and gloves.

Because no PHED or EPA-reviewed study data were available for occupational exposure from application of insecticide dust, an attempt was made to characterize the magnitude of exposure, and also the risk, by using a study from the scientific literature. The study selected was reported by David A. Kurtz⁷ and William M. Bode and reviewed by David Jaquith⁸ of HED. The study measured exposures by passive dosimetry of 12 volunteers applying three different formulations of carbaryl - dust, wettable powder, and aqueous suspension - to corn and beans in a garden for 15 minutes to each crop. The summary of the study and calculations are included as Appendix A. Although the assumption that clothing is 50% protective from dust is very conservative, and the dust formulation measured in the study was 5% ai (vs. Reldan 3%), the application scenario may not be conservative if applied to grain treatment. Because the worker applying dust to grain is standing in the grain, it is assumed the dermal exposure would be greater than dusting plants in a garden. However, this data is used to provide an initial attempt to characterize the applicator's dose (see Table 3).

Post-Application Exposure

Post-application risks include bystander exposure to dusts generated by grain being conveyed into, out of or within storage containers, and dermal exposure when sampling treated grain. Personnel rarely have direct contact with the stored grain and therefore skin exposure is only a concern during short exposures for testing of grain. Bystander dust exposure may be significant for either the employee of a grain elevator or farmer/operator who operates a portable auger to load treated grain into a bin.

Little data is available, however, to quantify these risks to workers. Bystander exposure to pesticide residues on grain dust, i.e., during off-loading to rail cars or vessels, is a potential health hazard (as is inhalation of the grain dust itself). One Canadian study of dock worker exposure during treated grain loading showed individual exposures to airborne malathion levels were well below the occupational exposure limit.³ The study did not cover all operations, however. A study published in 1984 found that levels of malathion in grain *dust* were 18-30 times higher than the permissible residue in grain *per se*, and may present a long-term, if not a short-term health hazard.⁴ In general, where dusty conditions exist, exhaust systems and respirators, if necessary, should be used to limit worker exposure to grain dust and insecticides.

IV. Residential Exposure Assessment

There is currently no registered use for this pesticide that could result in residential exposure.

V. Risk Characterization / Risk Assessment

Special Concern

There is inadequate data on application of insecticidal dust in either PHED or the literature. The application of Reldan 2% or 3% dust as stated on the label is considered by HED to be a significant potential exposure hazard.

Margins of Exposure (MOE)

For occupational short-term (7 days or less) dermal and inhalation exposure risk assessments, a NOAEL of 1 mg/kg/day was selected based on RBC cholinesterase inhibition in a rat developmental toxicity study. For intermediate (less than 180 days) or long-term (more than 180 days) dermal and inhalation exposure, a NOAEL of 0.1 mg/kg/day was selected based on inhibition of plasma cholinesterase at 90 days in a chronic/oncogenicity feeding study in rats.

For chlorpyrifos methyl the combined loader and applicator total dermal and inhalation risk does not exceed the Agency level of concern (MOE of 100) for short-term exposures (7 days or less) for the scenarios for which surrogate data is available when long sleeved shirt and long pants and gloves are

worn. See **Table 5: Chlorpyrifos Methyl: Summary of Combined Dermal and Inhalation MOEs.** There are no chemical specific studies or surrogate data that adequately characterize the application of the dust formulation. The combined dermal and inhalation MOEs for all available exposure scenarios (short- and intermediate-term) without gloves exceed the Agency's level of concern except for short-term mixing and loading liquids. The combined intermediate-term MOEs also exceed the Agency's level of concern, except for mixing and loading. It should be noted that the mixer/loader for automated grain treatment could conceivably load 10 times the estimated quantity at a large grain elevator in harvest season, resulting in ten-fold higher exposures and 10-fold lower MOEs. Several exposure scenarios (i.e., treating grain in truck or grain bin by hand or mechanical means with dust) have no data available. An attempt was made to characterize dermal short-term exposure to dusts based on exposure studies of application of dust to gardens. The MOEs calculated for the dust application (dermal exposure only) exceeded the Agency level of concern, with a maximum MOE of 21. Only the mixer/loader of liquid formulation scenario has an adequate MOE for more than a 7 day exposure.

Using the exposure estimates of Kurtz & Bode to extrapolate dust exposure while top-dressing grain in bins or treating grain in trucks provided MOEs below 100 for both short and intermediate-term exposures. This model and the estimates based on the model are, again, provided for range finding purposes only. There is insufficient data to characterize the scenario as adequately conservative because more or less grain may be treated per day than is characterized here. The scenario is based on unpublished information and the best judgement of HED and agricultural consultants. Other PHED scenarios for use of dust in shaker cans give unit exposures both lower and higher than those of Kurtz & Bode, indicating these estimates may be reasonable for a garden scenario.

Data Gaps:

No inhalation exposure data was available for hand application of dusts. Studies of occupational exposure to insecticidal dust are needed.

Table 1. Exposure Scenario Descriptions for Uses of Chlorpyrifos Methyl

Exposure Scenario (Number)	Data Source	Standard Assumptions ^a (8-hr work day)	Comments ^b
Mixer/Loader Exposure			
Loading Dust for Automatic Dispenser (1) [Closest scenario is mixing and loading wettable powder]	PHED V 1.1	800 lbs of 3% dust [80,000 bu]	<p>Single Layer, No Gloves: "Best Available" grades: Hands, dermal, and inhalation ABC grades. Hands = 7 replicates; Dermal = 25 to 45 replicates; Inhalation = 44 replicates. Low confidence due to low number of hand replicates.</p> <p>Single Layer, Gloves: "Best Available" grades: Hands and dermal ABC grades. Hands = 24 replicates; Dermal = 22 to 45 replicates. Inhalation = 44 replicates, ABC grade. Medium confidence in dermal and inhalation data.</p> <p>Additional PPE: 50% Protection Factor for coveralls on affected body parts; 80% Protection Factor for use of dust/mist respirator.</p>
Mixing and Loading Liquids (2)	PHED V1.1	40 gallons per day for high pressure handwand sprayer; 400 gallons (1%) per day for automated admixture system	<p>Single Layer, No Gloves: "Best Available" grades: Hands, dermal, and inhalation AB grades. Hands = 53 replicates; Dermal = 72 to 122 replicates; Inhalation = 85 replicates. High confidence in dermal data; high confidence in inhalation data.</p> <p>Single Layer, Gloves: "Best Available" grades: Hands and dermal acceptable grades. Hands = 59 replicates; Dermal = 25 to 122 replicates. High confidence in dermal and inhalation data.</p> <p>Additional PPE: 50% Protection Factor for coveralls on affected body parts; 80% Protection Factor for use of dust/mist respirator.</p>
Mixer/Loader/Applicator Exposure			

Exposure Scenario (Number)	Data Source	Standard Assumptions ^a (8-hr work day)	Comments ^b
Mixer/Loader/Applicator			
Applying Dust by Hand or Power Duster (3, 4)	Kurz, D. and Bode, W. 1985	No Std. Assumptions: See Table 2	For Dermal exposure only: non-guideline study; 24 replicates per formulation; see study review by D. Jakowitz in Appendix.
Backpack Sprayer (5)	PHED V1.1	24 gallons	<p>Single Layer, No Gloves: "Best Available" grades: Hands and dermal grades AB; Inhalation acceptable grades. Hands = 0 replicates; Dermal = 9 to 11 replicates; Inhalation = 11 replicates. Low confidence in dermal and inhalation data due to inadequate replicate number.</p> <p>Single Layer, Gloves: Hands = 11 replicates, C grade. Dermal = 9 to 11 replicates, AB grade; Inhalation 11 replicates acceptable grade.</p> <p>Additional PPE: 50% Protection Factor for coveralls on affected body parts; 80% Protection Factor for use of dust/mist respirator.</p>
High Pressure Handwand (6)	PHED V1.1	40 gallons	<p>Single Layer, No Gloves: "Best Available" grades: Dermal AB grade, and inhalation A grade. Dermal = 7 to 13 replicates; Hand data not available for "no glove" scenario; Inhalation = 13 replicates. Low confidence in dermal and inhalation data due to inadequate replicate numbers.</p> <p>Single Layer, Gloves: "Best Available" grades: Dermal AB grade, hands C grade, inhalation A grade. Dermal = 7 to 13 replicates; Hands = 13 replicates. Low confidence due to inadequate replicate numbers.</p> <p>Additional PPE: 50% Protection Factor for coveralls on affected body parts; 80% Protection Factor for use of dust/mist respirator.(baseline includes gloves).</p>

^a Standard Assumptions based on an 8-hour work day as estimated by EPA/HED. BEAD data were not available.

^b "Best Available" grades are defined by EPA/HED SOP for meeting Subdivision U Guidelines. Best available grades are assigned as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B, and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality and number of replicates. Data confidence are assigned as follows:

High = grades A and B and 15 or more replicates per body part
Medium = grades A, B, and C and 15 or more replicates per body part
Low = grades A, B, C, D, and E or any combination of grades with less than 15 replicates

Table 2: Assumptions Used in Estimating Worker Short and Intermediate-Term Exposure to Chlorpyrifos methyl

Exposure Scenario (Scenario #)	Application Rate (lb ai/gal or /1000 ft ² or /1000 bu.) ^a	Daily Bushels, Ft ² , or Gallons Treated ^b
Mixer/Loader Exposure		
Loading Dusts for Automated Application Systems (1)	10 lb Reldan 2-3%/1000 bu = 0.2-0.3 lb ai/1000 bu	10,000 bu/hr*8hrs= 80,000 bu
Mixing/Loading Liquids for Automated Application (2) [ex: wheat]	1% solution = 8oz Reldan 4E / 3 gal H2O x 5gal/1000 bu = 0.42 lb ai/1000 bu	10,000 bu/hr*8hrs= 80,000 bu
Mixer/Loader/Applicator Exposure		
Handheld Dust Pump (3) for (a) treating wagon or truckload or (b) top dressing grain in storage container	10 lb Reldan 3%/1000 bu = 0.3 lb ai/1000 bu 7 lb Reldan 2-3%/1000 ft ² = 0.21 lb ai/1000 ft ²	300-1000 bu / farm wagon or truck * 10 or 7 bins/day = 3,150 ft ²
Power Duster (4) for (a) treating wagon or truckload or (b) top dressing grain	b)10 lb Reldan 2-3%/1000 bu = 0.3 lb ai/1000 bu a)7 lb Reldan 2-3%/1000 ft ² = 0.21 lb ai/1000 ft ²	300-1000 bu / farm wagon or truck * 10 or 7 bins/day = 3,150 ft ²
Backpack Sprayer (5) for Grain Bin and Warehouse (for spraying walls)	1% = 8oz Reldan 4E / 3 gal H2O= 0.25 lb ai/3gal 1 gal 1% solution/650 ft ²	24 gal (diluted) (15,600 ft ²)
High Pressure Handwand (6) (for spraying walls)	1% = 8oz Reldan 4E / 3 gal H2O= 0.25 lb ai/3gal 1 gal 1% solution/650 ft ²	40 gal (diluted) 26,000 ft ²

^a The 3% dust has been used for simplicity of calculations, as they are more conservative than using the 2% dust; consequently scenarios which have adequate MOEs for 3% dust will also have adequate MOEs for 2% dust.

^b Daily area treated (or gallons applied) values are from EPA HED estimates of area (or gallons) that could be treated in a single day for each exposure scenario of concern. Assistance was received from Agricultural Extension Agents. For example:

- Estimate of Mixer/Loader exposure for application of liquid Reldan 4E (43% ai) to grain (wheat):
wheat application rate for final concentration of 6 ppm = 11.5 oz product/5gal water/1000 bushels
= 0.09 gal product / 5 gallons water/ 1000 bu; = 0.09 gal * 4 lb ai/ gal; = 0.36 lb ai / 1000 bu;
estimated 80,000 bushels/day [10,000 bu/hr loading * 8 hrs] * 0.36 lb ai/ 1000 bu = 29 # ai/day
- Hand-held duster application for truck load treatment assumes 1000 bushels/truck load.
- Hand-held duster application for grain top-dressing assumes 60,000 bu bins @ 450 ft² * 7 / day = 3150 ft²
- Insufficient data to characterize application rate for power duster in truck, bin, or silo
- Backpack sprayer (3 gallons) assumed to apply maximum of 8 tanks per day due to practical limitations, assuming one person mixing, loading and applying (MLAP). Therefore 3 gal/tank * 8 tanks=24 gal * 650 ft² /gal= 15,600 ft²; 0.25 lb ai/tank * 8 tanks = 2 lb ai/day.
- High pressure handwand application assumed to apply maximum of 40 gallons per day = 40gal * 650 ft² /gal = 26,000 ft² ;
40gal/day * 0.25 lb ai/3gal tank = 3.3 lb ai/day.

**Table 3. Occupational Handler Short- and Intermediate-Term Exposure Estimate and Risk Assessment Summary
for Chlorpyrifos Methyl**

		DERMAL					INHALATION					Combined MOE	
		(With minimum PPE) ^a					(With no respirator)					Min. PPE	
Application Scenario	(lb ai/ day)*	UE ^b mg/lb a.i.	ADD ^c (mg/kg/day)		ST MOE ^d NOAEL = 1 mg/kg	Int. MOE ^d NOAEL = 0.1 mg/kg	UE ^e mg /lb ai	ADD ^f (mg /kg/day)		ST MOE ^d NOAEL= 1 mg/kg	Int. MOE ^d NOAEL = 0.1 mg/kg	MOE Total ^g	
			Short -term	Inter .- term				Short- term	Inter.- term			Short Term	Inter. Term
Mixer/Loader													
Open Loading Dusts [Wettable Powder] for Automated Application Systems (1)	24	0.17	2.0 E-3	1.8 E-3	500	56	0.0434	0.017	0.015	59	6.7	53	6.0
Mixing/Loading Liquids for Automated Application (2)	29	0.023	3.3 E- 4	3.3 E-4	3000	340	0.0012	5.8 E-4	5.0 E-4	1700	200	1000	130
Mixer/Loader/Applicator													
3a)Treating Grain in Truck or (b)Top-Dressing Grain with Dust by Hand-Pump	3	200	0.30	0.26	3.3	0.39	No Data						
	0.66		0.066	0.05 7	15	1.8							
4a)Treating Grain in Truck or b) Top-Dressing Grain with Dust by Power Duster	No Data												
Backpack Spraying (5)	2	2.5	2.5 E- 3	2.1 E-3	400	48	0.03	1.0 E-3	8.6 E-4	1000	120	290	34
High Pressure Handwand Sprayer (6)	3.3	2.5	4.1 E- 3	3.5 E-3	240	28	0.12	6.6 E-3	5.7 E-3	150	18	93	11

*There are 2 strengths of dust, but the 3% was selected for calculations as they will be more conservative and thus suffice for 2% as well.

^a The minimum PPE for loaders is long sleeve shirt, long pants, shoes and socks, eye protection, and chemical resistant gloves.(Note: the label does not specify long sleeves or long pants).

The minimum PPE for applicators is long sleeve shirt, long pants, chemical resistant gloves, and shoes with socks.

^b UE = Dermal Unit Exposure is the amount of exposure measured in terms of mg a.i./lb a.i handled

^c ADD(mg/kg/day)[dermal]: = unit exposure (UE) from PHED in mg/lb a.i. handled * lb a.i./day * 0.03 (dermal absorption) / 70 kg wt.

^d MOE = NOAEL/ADD; Short-term NOAEL dermal and inhalation = 1.0 mg/kg bw; Intermediate or Long-term NOAEL = 0.1 mg/kg bw

^e UE = Unit Exposure for inhalation is expressed in terms mg a.i./lb a.i. handled.

^f ADD(mg/kg/day) [inhalation] = unit exposure (UE) from PHED in mg/lb a.i. handled * lb a.i./day / 70 kg wt

^g MOE Total = NOAEL/ (ADD [dermal] + ADD [inhalation]); the ADDs are based on a common endpoint

**Table 4. Occupational Handler Short- and Intermediate-Term Exposure Estimate and Risk Assessment Summary
for Chlorpyrifos Methyl**

		DERMAL					INHALATION					Combined MOE	
		(With Maximum PPE) ^a					(With Dust/Mist Respirator)					Max. PPE	
Application Scenario	(lb ai/ day)*	UE ^b mg/lb a.i.	ADD ^c (mg/kg/day)		Short- Term MOE ^d NOAEL = 1 mg/kg	Int.- Term MOE ^d NOAE L = 0.1 mg/kg	UE ^e mg /lb ai	ADD ^f (mg/kg/day)		Short-Term MOE ^d NOAEL= 1 mg/kg	Int.-Term MOE ^d NOAEL = 0.1 mg/kg	MOE Total ^g	
			Short- term	Inter- term				Short- term	Inter- term			Short Term	Inter. Term
Mixer/Loader													
Open Loading Dusts [Wettable Powder] for Automated Application Systems (1)	24	0.132	1.6 E-3	1.4 E-3	620	71	8.7 E-3	3.5 E-3	3.0E-3	290	33	200	23
Mixing/Loading Liquids for Automated Application (2)	29	0.017	2.5 E-4	2.1E-4	4,000	480	2.4 E-4	1.2 E-4	9.9E-5	8,300	1000	2700	320
Mixer/Loader/Applicator													
3a)Treating Grain in Truck or (b)Top-Dressing Grain with Dust by Hand-Pump	3	143	0.21	0.18	4.7	0.54	No Data						
	0.66		0.47	0.040	21	2.5							
4a)Treating Grain in Truck or b) Top-Dressing Grain with Dust by Power Duster	No Data												
Backpack Spraying (5)	2	1.6	1.6E-3	1.4E-3	620	71	0.006	2.0 E-4	1.7E-4	5000	590	560	64
High Pressure Handwand Sprayer (6)	3.3	1.6	2.6 E-3	2.3E-3	380	44	0.024	1.3 E-3	1.1E-3	770	91	260	29

* There are 2 strengths of dust, but the 3% was selected for calculations as they will be more conservative and thus suffice for 2% as well.

^a The maximum dermal PPE for loaders and applicators is coveralls over long sleeve shirt, long pants and shoes with socks, eye protection, waterproof gloves.

^b UE = Dermal Unit Exposure is the amount of exposure measured in terms of mg a.i./lb a.i handled; 50% body protection factor for coveralls

^c ADD(mg/kg/day)[dermal]: = unit exposure (UE) from PHED in mg/lb a.i. handled * lb a.i./day * 0.03 (dermal absorption) / 70 kg wt.

^d MOE = NOAEL/ADD; Short-term NOAEL dermal and inhalation = 1.0 mg/kg bw; Intermediate or Long-term NOAEL = 0.1 mg/kg bw

^e UE = Unit Exposure for inhalation is expressed in terms mg a.i./lb a.i. handled.; 80% protection factor for dust/mist respirator use

^f ADD(mg/kg/day) [inhalation] = unit exposure (UE) from PHED in mg/lb a.i. handled * lb a.i./day / 70 kg wt

^g MOE Total = NOAEL/ (ADD [dermal] + ADD [inhalation]); the ADDs are based on a common endpoint

Table 5. Chlorpyrifos Methyl: Summary of Combined Dermal and Inhalation MOEs Best Estimate Application Rate				
Scenario	Minimum PPE (Single Layer, Gloves)		Maximum PPE (Coveralls + Respirator)	
	Short Term	Intermediate Term	Short Term	Intermediate Term
Mixer/Loader				
Loading Dust (1)	53	6.0	200	23
Mixing/Loading Liquid (2)	1100	130	2700	320
Mixer/Loader/Applicator				
Hand-Held Duster (3a) Treating Grain in Truck (3b) Top-Dressing Grain	3.3 [dermal]	0.39 [dermal]	4.7 [dermal]	0.54 [dermal]
	15 [dermal]	1.6 [dermal]	21 [dermal]	2.5 [dermal]
Power Duster (4)	ND	ND	ND	ND
Backpack Spraying (5)	290	34	560	64
MLAP High Pressure Handwand Sprayer (6)	93	11	260	29

ND = No Data

MLAP = Mixer/Loader/Applicator

MOE > 100 do not exceed HED's level of concern

REFERENCES

1. USEPA, Series 875 Occupational and Residential Exposure Test Guidelines: Group A and B Exposure Monitoring Test Guidelines, 1997
2. Martin, MA. Edwards, CR. et al. Stored Wheat IPM Practices and Pesticide Use in Key regions of the United States and Canada: 1996. Agricultural research Programs Purdue University. April 1997.
3. Dimich-Ward, H. Dittrick, M. Graf, P. "Survey of Malathion Exposure among Elevator and Dock Workers Who Handle Grain. Canadian Journal of Public Health. (87) 2. March-April 1996. Pp 141-2.
4. Palmgren, MS. Lee, TC. "Malathion and Diazinon Levels in Grain Dust from New Orleans Area Grain Elevators." Tulane University School of Public Health and tropical Medicine Environmental Health Sciences. American Industrial hygiene Association Journal. 45(3). March, 1984, 168-171.
5. Blondell, J. and Spann M.F., "Review of Chlorpyrifos Methyl Incident Reports, DP Barcode D251994, Chemical # 059102, Reregistration Case #0100." EPA HED. April 15, 1999.
6. Doherty, J., "Chlorpyrifos-Methyl - Toxicology Endpoint Selection - Report of the Hazard Identification Assessment Review Committee." EPA HED. April 29, 1999.
7. Kurtz, D.A. and W.M. Bode (1985) Application Exposure to the Home Gardener IN: Dermal Exposure Related to Pesticide Use American Chemical Society Symposium Series 273, R.C. Honeycutt, G. Zweig, and N.N. Ragsdale Eds, American Chemical Society , Washington, D.C.
8. Jaquith, D. Documentation of Applicator Exposure Assessment for Chlorpyrifos Reregistration Eligibility Document - Application in the Residential Environment. Memorandum to Chlorpyrifos File. EPA HED. June, 1996.

D265058

APPENDIX A

CITATION: Kurtz, D.A. and W.M. Bode (1985) Application Exposure to the Home Gardener IN: Dermal Exposure Related to Pesticide Use American Chemical Society Symposium Series 273, R.C. Honeycutt, G. Zweig, and N.N. Ragsdale Eds, American Chemical Society , Washington, D.C.

Dermal exposure of home gardeners was monitored during application of the insecticide carbaryl. The investigation included evaluation of dust, wettable powder, and aqueous suspension formulations containing 5, 50, and 43 percent active ingredient, respectively. The dust was applied using either a shaker or a dust pump. The wettable powder and aqueous suspension were both applied using hand held pressurized tank equipment. The insecticide was applied to two representative crops, corn (1.0-1.3 m height) and beans (0.2-0.3 m high).

Applicators were volunteers selected from the community. The volunteers were told to apply the pesticide according to the label instructions. Each applied all three formulations to corn and/or beans. A total of 24 replicates, 12 with each crop, were monitored for each formulation. An exposure replicate included filling the unit, applying the compound, and emptying the equipment after treatment. Fifteen minutes, timed by an observer, were allowed for each replicate. Two of the treatments with dust were conducted using a ready-to-use shaker can. One tablespoon of the wettable powder or aqueous suspensions was used with one gallon of water in the compressed air sprayers.

Dermal exposure of the body was measured using gauze pads attached to the outside of a Tyvek suit. A description of the patch locations is presented in Table A-1. Dermal exposure of the hands was measured by hand rinse with 200 ml of 0.03% NaOH in ethanol. A 20 ml aliquot was selected for analysis. Twenty milliliter samples were also collected from the spray wand before and after application to confirm the amount of active ingredient handled. The mean amounts of active ingredient applied during the treatments are presented in Table A-2.

The pads were extracted with methanol containing 0.03 percent NaOH. Ethanol was used in the hand washes to avoid the toxicity problems that could arise with methanol. Samples were analyzed within 6 hours of collection to minimize breakdown of carbaryl. Recoveries from six gauze pads, fortified in the field at levels of 10 Fg and 50 Fg, were 101 and 98 percent, respectively. Similar recoveries from ethanol solutions spiked at 50 and 200 Fg levels were 144 and 189 percent, respectively.

Dermal exposures were estimated for clothing scenarios ranging from no protection from clothing to long sleeves and long pants (50% protection) with gloves (90% protection). These values are presented in Tables A-3 and A-4, for dust and liquid applications, respectively. Due to the similarities in the exposure scenarios and the data obtained the results of the trials with the wettable powder and aqueous suspension were averaged before exposure calculations were conducted. The assumption of 50 percent protection from clothing is probably very conservative in the case of the dust formulation. Respiratory exposure was not measured. The underlying assumption was that clothing offered complete protection to covered areas. The residue levels found on dermal pads or on the hands are presented in Tables A-5 to A-7.

Table A-1. Body Areas Monitored for Dermal Exposure to Carbaryl
During Home Garden Application.

Body Part	Pad Location/ Dosimeter	Pad Area (cm ²)
Face, front of neck	Face mask	120
Shoulder, upper arms	Top of shoulders	50
Back	Upper back	25
Chest	Upper chest	25
Forearms	Forearms	25 each
Hand	Hand wash	Entire hand
Thigh	Thighs	25 each
Lower leg	Cuff	25 each
Ankle	Shoe vamps	2.5 each ¹
Foot	Top of feet	25 each

¹ Area for exposure calculation, hidden area = 22.5 cm²

Table A-2. Mean Amounts of Carbaryl Applied to Gardens in 15 Minutes

Formulation	Crop	Amount Applied		
		Formulation	Active Ingredient	(g)
Dust	Corn	190 g		9.5
	Beans	220 g		11
Wettable powder	Corn	2.8 L		2.1
	Beans	2.9 L		2.8
Aqueous suspension	Corn	2.8 L		3.2
	Beans	2.9 L		3.0

Table A-3. Potential Dermal Exposures of Home Gardeners to a Dust Formulation of Carbaryl in 15 minutes of treatment.

Body Part	Clothing Factor	Surface Area (cm ²)	Dermal Exposure (micrograms)		
			No Protection	Long sleeves, gloves	Short sleeves, no gloves
Face	1.0	1300	660	660	660
Shoulders	0.5	2910	361	180	180
Back	0.5	3550	483	241	241
Chest					
Right	0.5	1775	533	266	266
Left	0.5	1775	422	211	211
Forearms					
Right	0.5	605	215	108	215
Left	0.5	605	120	60	120
Hands					
Right	0.9	410	128	13	128
Left	0.9	410	108	11	108
Thighs					
Right	0.5	1910	680	340	340
Left	0.5	1910	1131	565	565
Lower leg					
Right	0.5	1190	1380	690	690
Left	0.5	1190	1833	916	916
Shoe					
Right	0.9	655	1179	118	118
Left	0.9	655	1376	138	138

TOTAL DERMAL EXPOSURE

(Fg/15 min.)	1.1 x 10 ⁴	4.5 x 10 ³	4.9 x 10 ³
Fg per hr:	4.4 x 10 ⁴	1.8 x 10 ⁴	2.0 x 10 ⁴
Mean g ai handled:	1.0	1.0	1.0
Fg per lb ai:	5.0 x 10 ⁶	2.0 x 10 ⁶	2.2 x 10 ⁶
mg per lb ai:	5.0 x 10 ³	2.0 x 10 ³	2.2 x 10 ³

Table A-4. Potential Dermal Exposures of Home Gardeners to Wettable Powder and Aqueous Suspension Formulations of Carbaryl.

Body Part	Surface Area	Clothing Factor	Wettable Powder	Aqueous Suspension	Mean (No Protection)	Long sleeves, gloves	Short sleeves, no gloves
Face	1300	0.0	138	101	120	120	120
Shoulders	2910	0.5	169	239	204	102	102
Back	3550	0.5	256	873	565	282	282
Chest							
Right	1775	0.5	96	167	132	66	66
Left	1775	0.5	170	121	146	73	73
Forearms							
Right	605	0.5	28	120	74	37	74
Left	605	0.5	70	115	93	46	93
Hands							
Right	410	0.9	43	30	37	4	37
Left	410	0.9	33	32	33	3	33
Thighs							
Right	1910	0.5	871	1039	955	478	478
Left	1910	0.5	737	1039	888	444	444
Lower leg							
Right	1190	0.5	1095	1833	1464	732	732
Left	1190	0.5	1214	1476	1345	673	673
Shoe							
Right	655	0.9	996	1127	1062	106	106
Left	655	0.9	891	1205	1048	105	105
TOTAL DERMAL EXPOSURE (Fg/15 min.)					8.2 x 10 ³	3.3 x 10 ³	3.4 x 10 ³
Fg per hr:					3.3 x 10 ⁴	1.2 x 10 ⁴	1.4 x 10 ⁴
Mean g ai handled:					2.8	2.8	2.8
Fg per lb ai:					1.3 x 10 ⁶	5.4 x 10 ⁵	5.5 x 10 ⁵
mg per lb ai:					1.3 x 10 ³	5.4 x 10 ²	5.5 x 10 ²

Table A-5. Potential Dermal Exposures of Individuals to Carbaryl Dust Applied to Home Gardens. No Protection from Clothing is Assumed.

Body Part	Corn		Exposure		Beans		Exposure		Mean for Both Crops (Fg)
	Surface Area (cm ²)	Fg	Fg found ¹		Fg		Fg found ¹		
Face	1300	14.9	775	10.5	546		660		
Shoulders	2910		3.3	384	2.9	338		361	
Back	3550		3.2	454		3.6	511		483
Chest									
Right	1775		9.2	653	5.8	412		533	
Left	1775		8.0	568		3.9	277		422
Forearms									
Right	605		14.2	344		3.6	87		215
Left	605		4.4	106		5.5	133		120
Hands									
Right	410		11.8	194		3.8	62		128
Left	410		7.9	130	5.3	87		108	
Thighs									
Right	1910	13.2	1008		4.6	351		680	
Left	1910	24.0	1834	5.6	428		1131		
Lower leg									
Right	1190		22.0	1047		36.0	1714		1380
Left	1190	25.0	1190		52.0	2475		1833	
Shoe									
Right	655		37.0	969	53.0	1389		1179	
Left	655	39.0	1022		66.0	1729		1376	

TOTAL DERMAL EXPOSURE

(Fg/15 minutes):		1.1 x 10 ⁴		1.1 x 10 ⁴		1.1 x 10 ⁴
Fg/hr:	4.4 x 10 ⁴		4.4 x 10 ⁴		4.4 x 10 ⁴	
mean Fg handled:	9.5			11		10
Fg/lb ai	5.3 x 10 ⁵			4.5 x 10 ⁵		5.0 x 10 ⁵
mg/lb ai	5.3 x 10 ²			4.5 x 10 ²		5.0 x 10 ²

¹ Fg found, adjusted to a 25 cm² dosimeter.

Table A-6. Potential Dermal Exposures of Individuals to a Wettable Powder Formulation. No Protection from Clothing is Assumed.

Body Part	Corn			Beans			Mean for Both Crops
	Surface Area (cm ²)		Exposure Fg Fg found ¹		Exposure Fg Fg found ¹		
Face	1300		2.8 146	2.5	130 138		
Shoulders	2910		1.9 221		1.0 116		169
Back	3550	1.9	270	1.7	241		256
Chest							
Right	1775		1.8 128	0.9	64		96
Left	1775		3.8 270	1.0	71 170		
Forearms							
Right	605		1.6 39		0.7 17		28
Left	605		5.2 126	0.6	15		70
Hands							
Right	410		3.0 49	2.2	36		43
Left	410		2.7 44	1.3	21		33
Thighs							
Right	1910	22.0	1681 0.8	61		871	
Left	1910	17.0	1299	2.3	176		737
Lower leg							
Right	1190	12.0	571 34.0	1618		1095	
Left	1190	23.0	1095 28.0	1333		1214	
Shoe							
Right	655		32.0 838		44.0 1153		996
Left	655		40.0 1048	28.0	734		891
TOTAL DERMAL EXPOSURE							
(Fg/15 minutes):			7.8 x 10 ³	5.8 x 10 ³		6.8 x 10 ³	
Fg/hr:			3.1 x 10 ⁴		2.3 x 10 ⁴		2.7 x 10 ⁴
mean Fg handled:			2.1	2.8		2.5	
Fg/lb ai			1.7 x 10 ⁶		9.4 x 10 ⁵		1.3 x 10 ⁶
mg/lb ai		1.7 x 10 ³		9.4 x 10 ²		1.3 x 10 ³	

¹ Fg found, adjusted to a 25 cm² dosimeter.

Table A-7. Potential Dermal Exposures of Individuals to an Aqueous Suspension For No Protection from Clothing is Assumed.

Body Part	Corn		Beans		Mean for Both	
	Surface Area (cm ²)	Exposure Fg	Exposure Fg found ¹	Exposure Fg	Exposure Fg found ¹	Crops
Face	1300	1.9	99	2.0	104	101
Shoulders	2910	1.4	163	2.7	314	239
Back	3550	10.6	1505	241	873	
Chest						
Right	1775	3.9	277	0.8	57	167
Left	1775	2.0	142	1.4	99	121
Total	3550	5.9	419	2.2	156	288
Forearms						
Right	605	9.1	220	0.8	19	120
Left	605	8.7	211	0.8	19	115
Total	1210	17.8	431	39	235	
Hands						
Right	410	2.2	36	1.4	23	30
Left	410	2.4	39	1.5	25	32
Total	820	4.6	75	2.9	48	62
Thighs						
Right	1910	26.0	1986	92	1039	
Left	1910	22.0	1681	397	1039	
Total	3820	48.0	3667	489	2078	
Lower leg						
Right	1190	39.0	1856	1809	1833	
Left	1190	28.0	1333	1618	1476	
Total	2380	67.0	3189	3427	3308	
Shoe						
Right	655	41.0	1074	45.0	1179	1127
Left	655	41.0	1074	51.0	1336	1205
Total	1310	82.0	2148	96.0	2515	2332

TOTAL DERMAL EXPOSURE

(Fg/15 minutes):	1.2 x 10 ⁴	7.3 x 10 ³	9.5 x 10 ³
Fg/hr:	4.8 x 10 ⁴	2.9 x 10 ⁴	3.9 x 10 ⁴
mean Fg handled:	3.2	3.0	3.1
Fg/lb ai	1.7 x 10 ⁶	1.1 x 10 ⁶	1.4 x 10 ⁶
mg/lb ai	1.7 x 10 ³	1.1 x 10 ³	1.4 x 10 ³

¹ Fg found, adjusted to a 25 cm² dosimeter.